

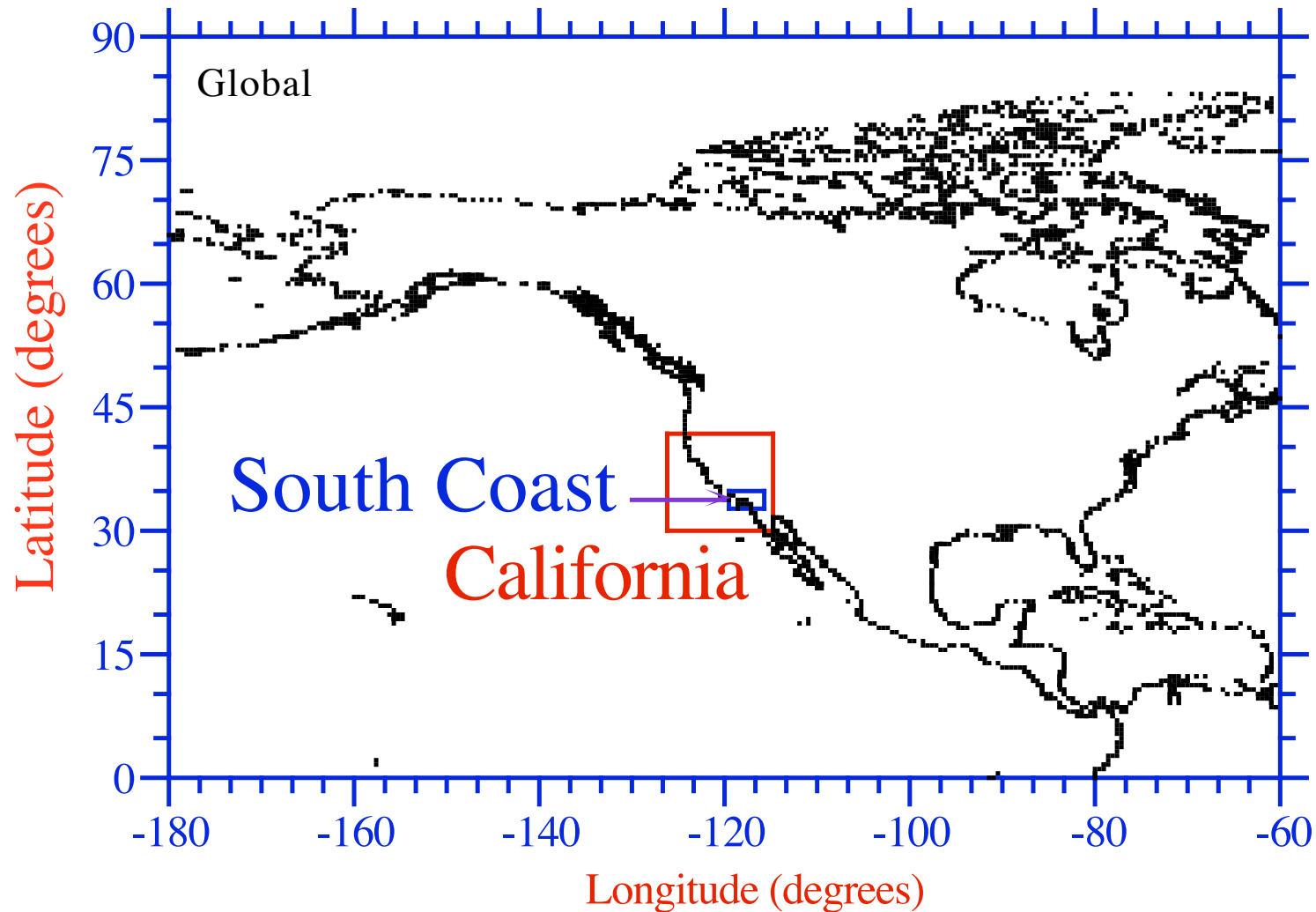
Numerical Study of the Effects of Aerosols and Irrigation on Snow, Rain, and Regional Climate in California

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Model Grids Treated for California Case



GATOR-GCMOM

Gas processes

- Emission
- Photochemistry
- Gas-to-particle conversion
- Cloud removal

Aerosol processes

- Emission
- Nucleation/condensation
- Gas dissolution
- Aqueous chemistry
- Crystallization
- Aerosol-aerosol coagulation
- Aerosol-cloud coagulation
- Dry deposition
- Sedimentation
- Rainout/washout

Meteorological processes

- Pressure, winds, temp., TKE

Cloud processes

- Time-dependent 3-D size-res. clouds
- Liquid/ice growth on aerosol particles
- Liquid drop freezing/breakup
- Hydrometeor-hydrometeor coagulation
- Hydrometeor-aerosol coagulation
- Precipitation, aer./gas rainout/washout
- Below-cloud evaporation/melting
- Lightning from collision bounceoffs

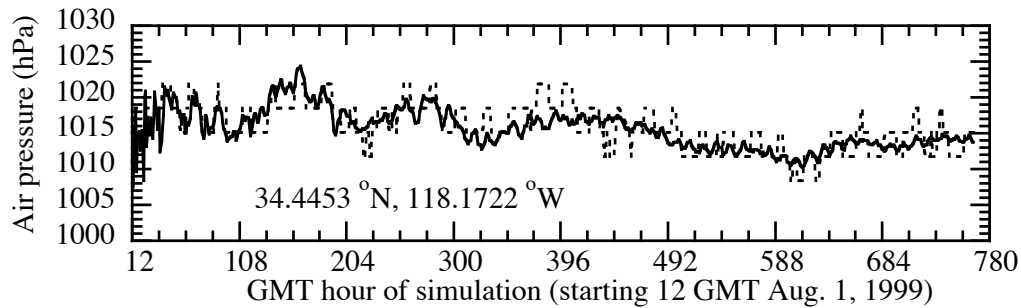
Radiative transfer

- UV/visible/near-IR/thermal-IR
- Gas/aerosol/cloud scat./absorption
- Predicted snow, ice, water albedos

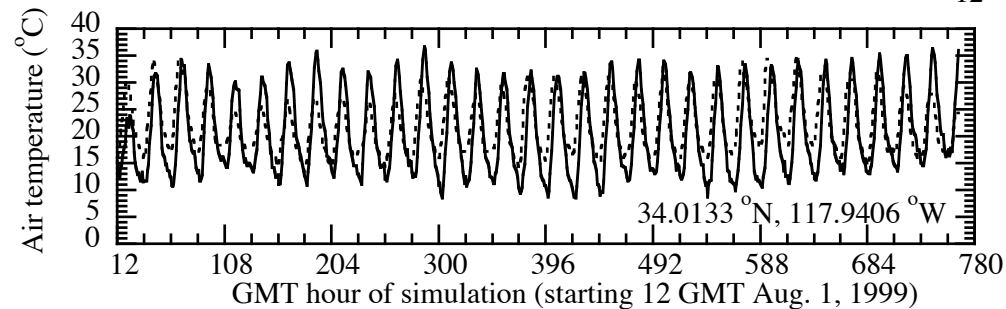
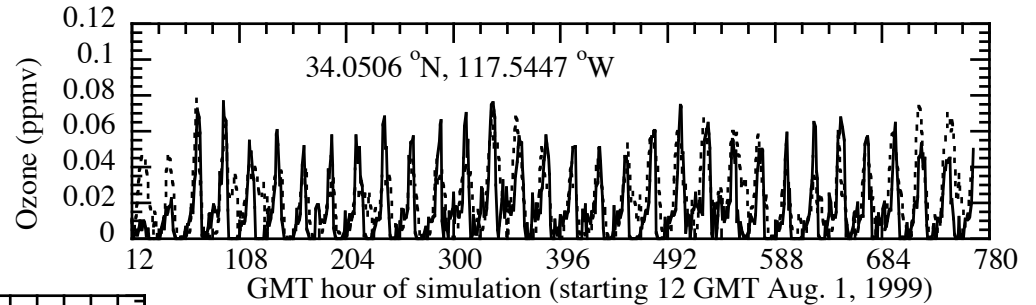
Surface processes

- Soil, water, snow, sea ice, vegetation, road, roof temperatures/moisture
- Ocean 2-D dynam., 3-D diffus/chem.
- Ocean-atmosphere exchange

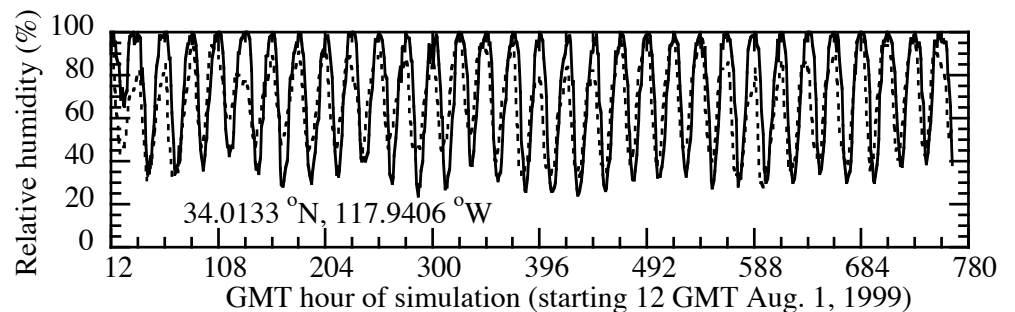
Model Versus Data (EPA)



Ozone

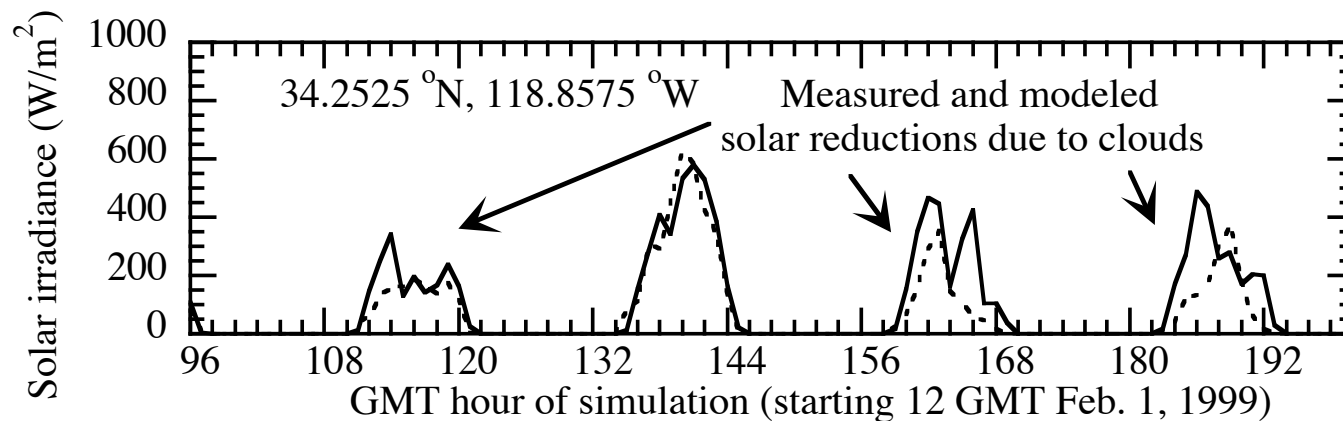
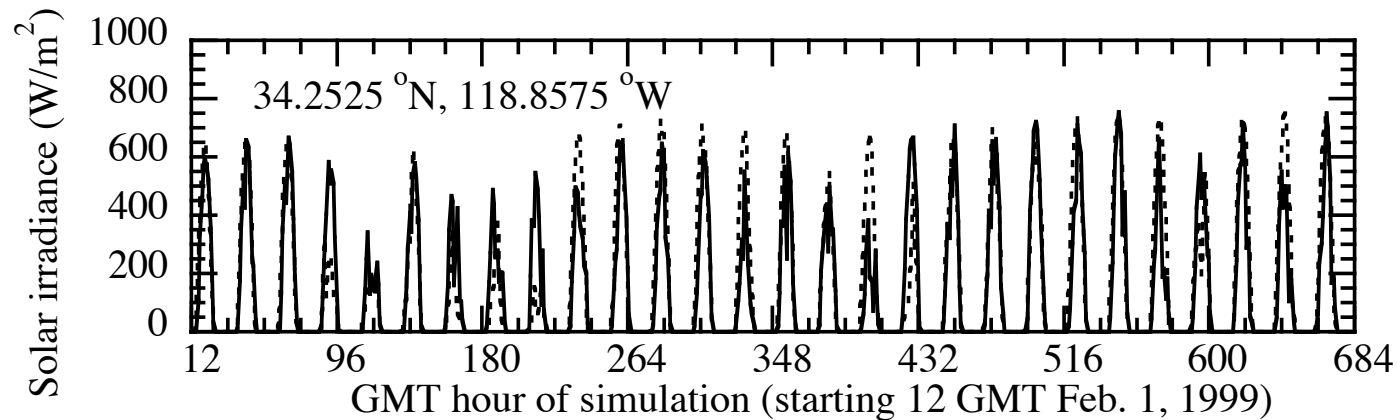


RH

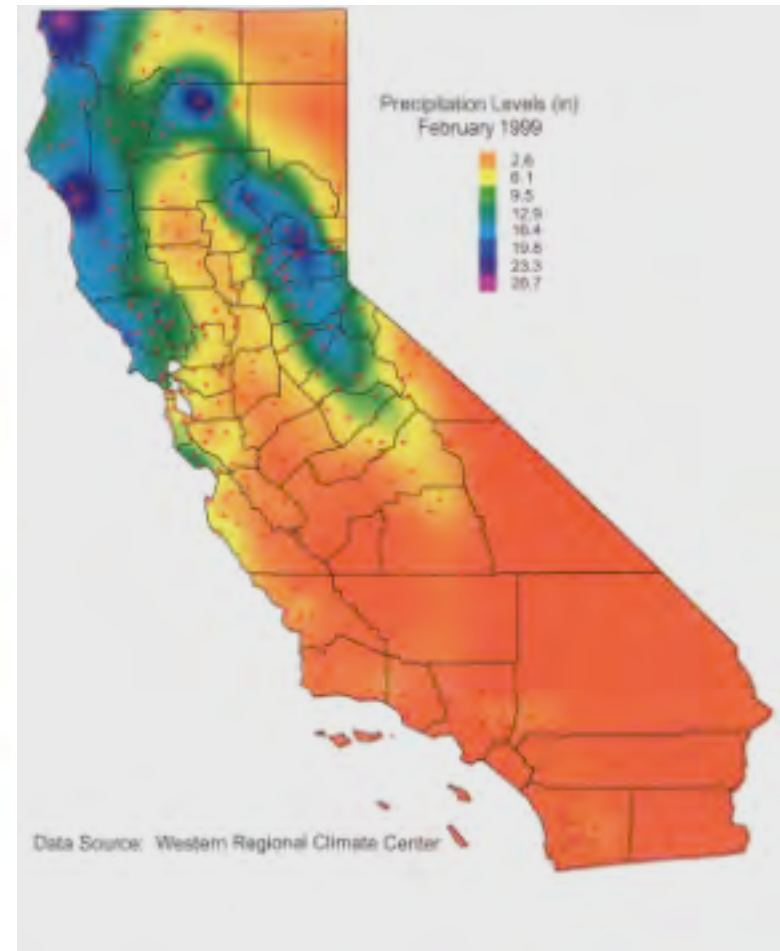
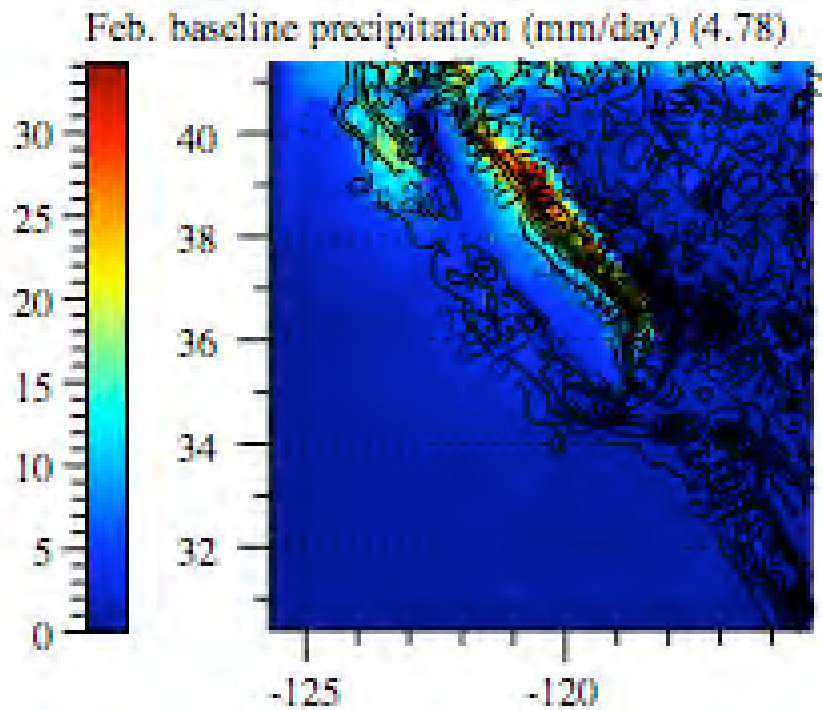


Temperature

Model Versus Measured Surface Solar Radiation

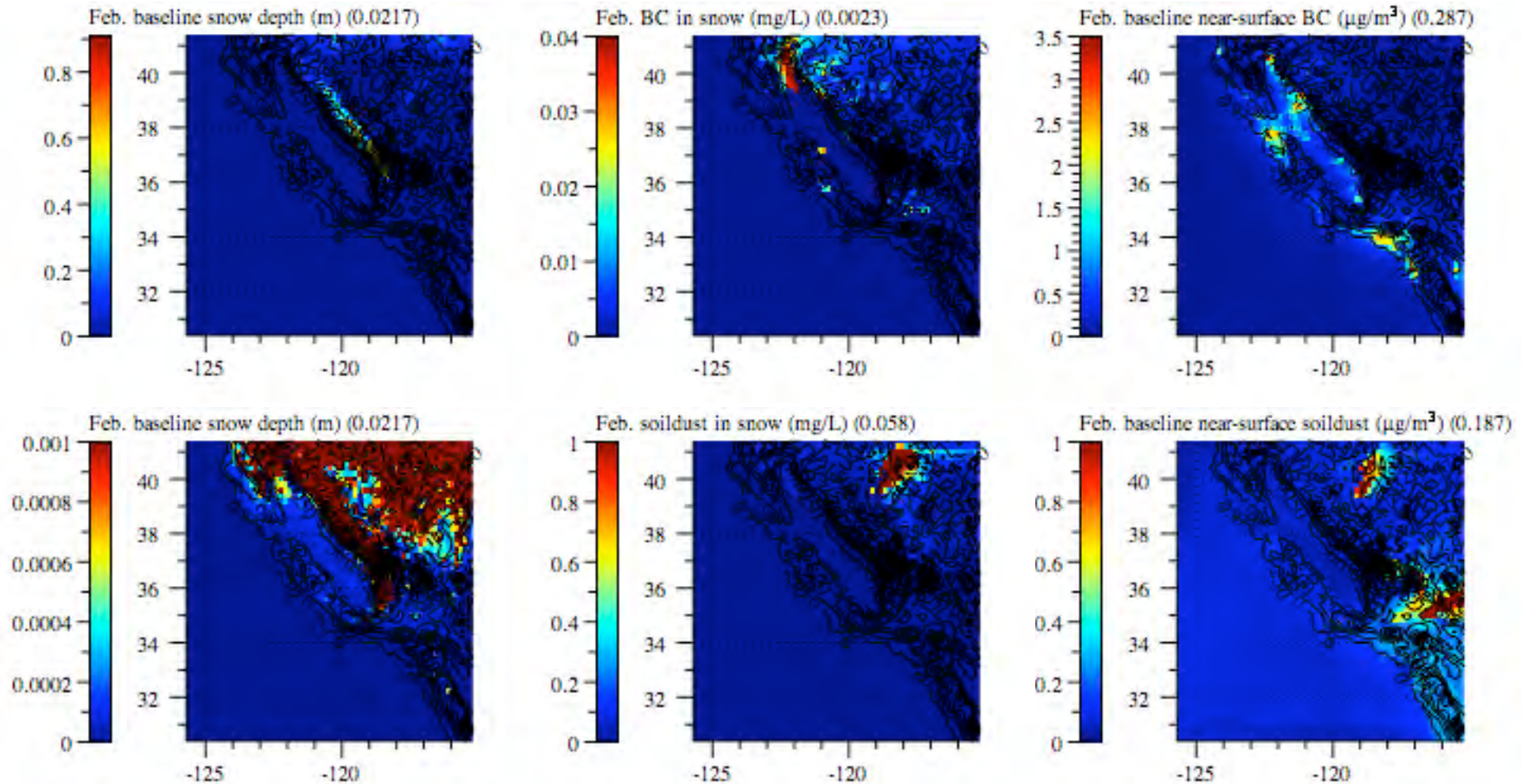


Modeled vs. Measured Feb. 1999 Precip.



Data from Western Reg. Clim. Ctr.
Prepared by G. Lopez, G. Franco,

Feb. Snow; BC/SoilDust in Snow/Aer

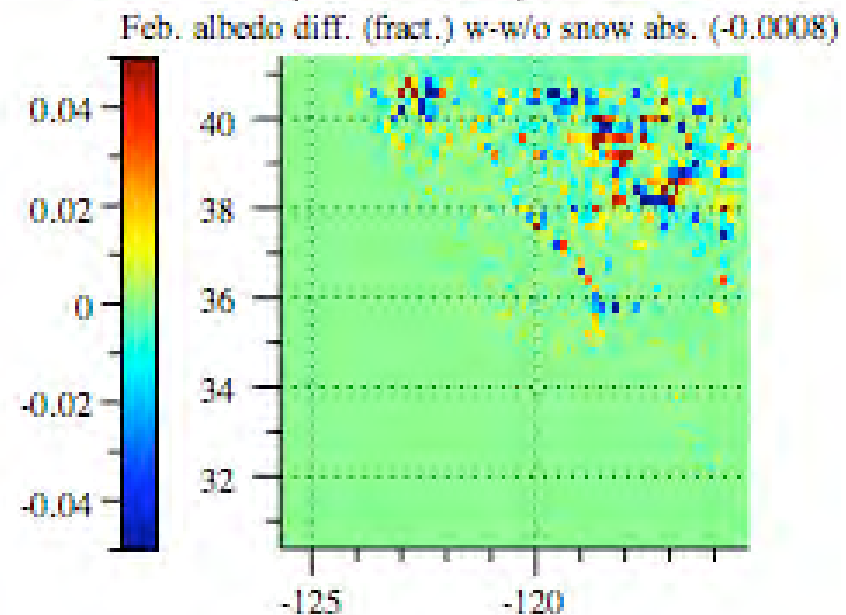
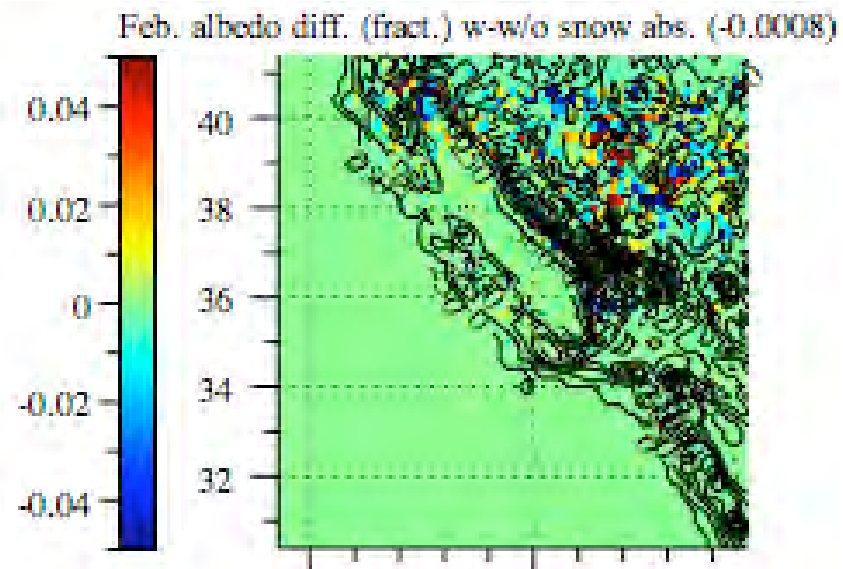
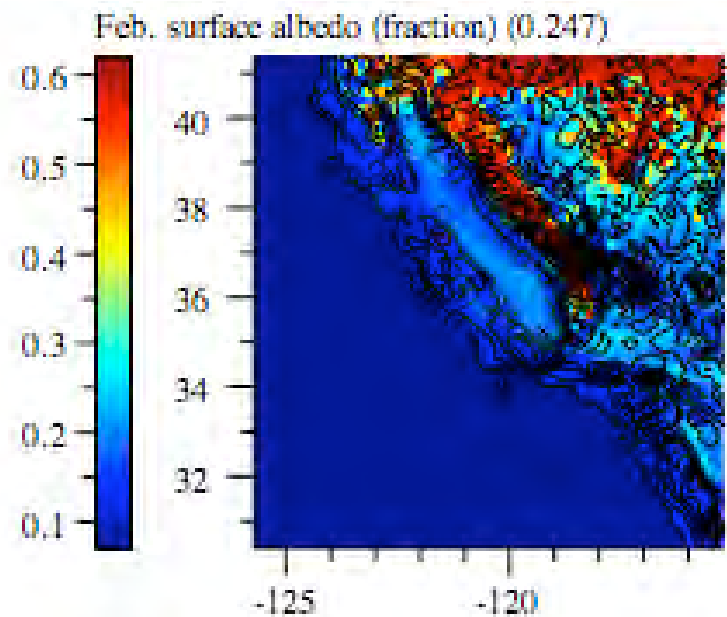


Snow depth

BC, Soildust in Snow

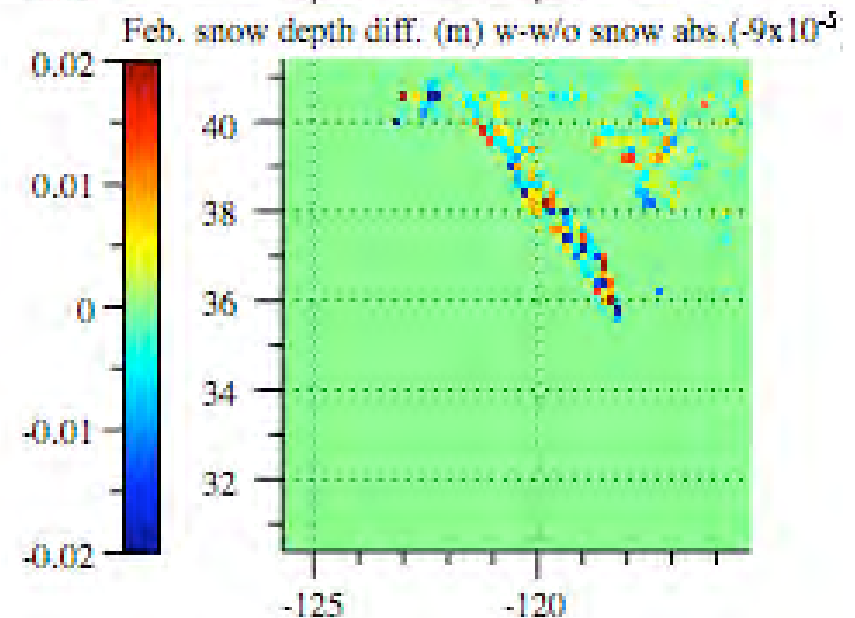
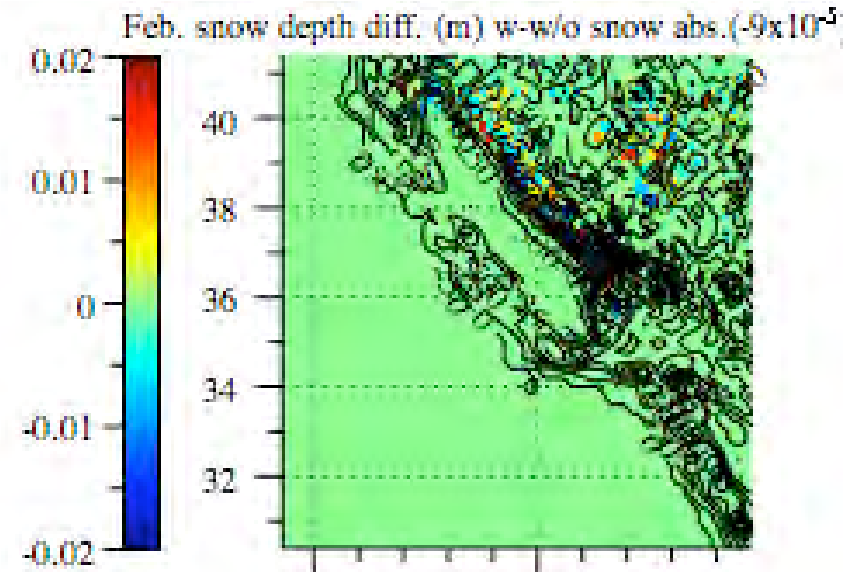
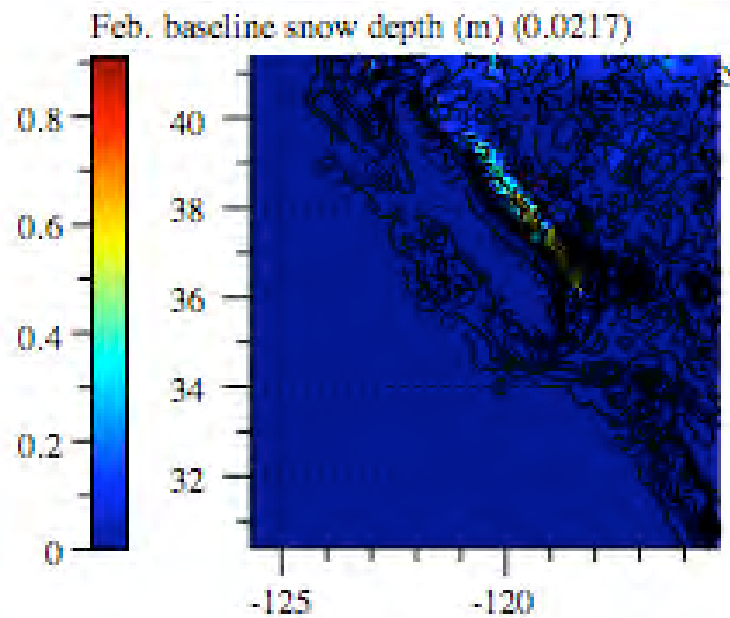
BC, Soildust in Aer.

Feb. Alb. and Diff. Due to Snow Abs.



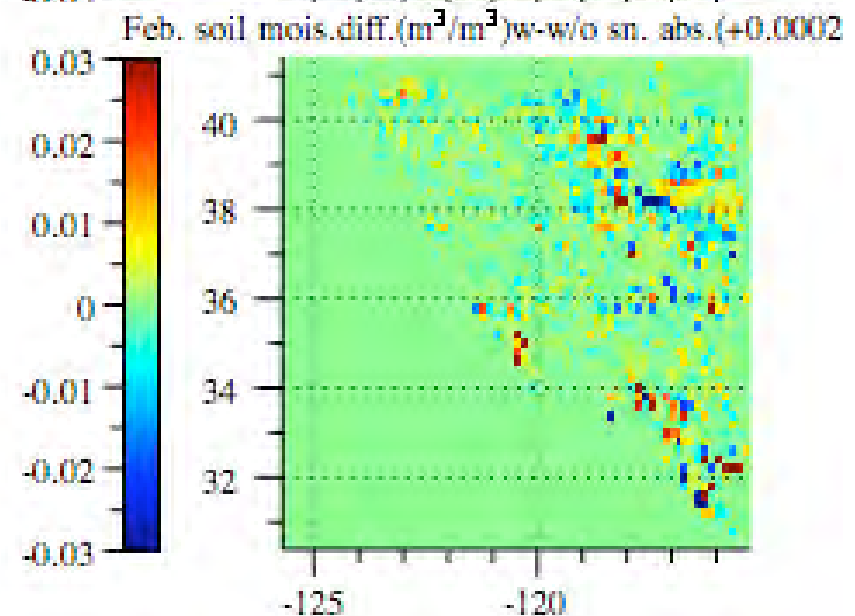
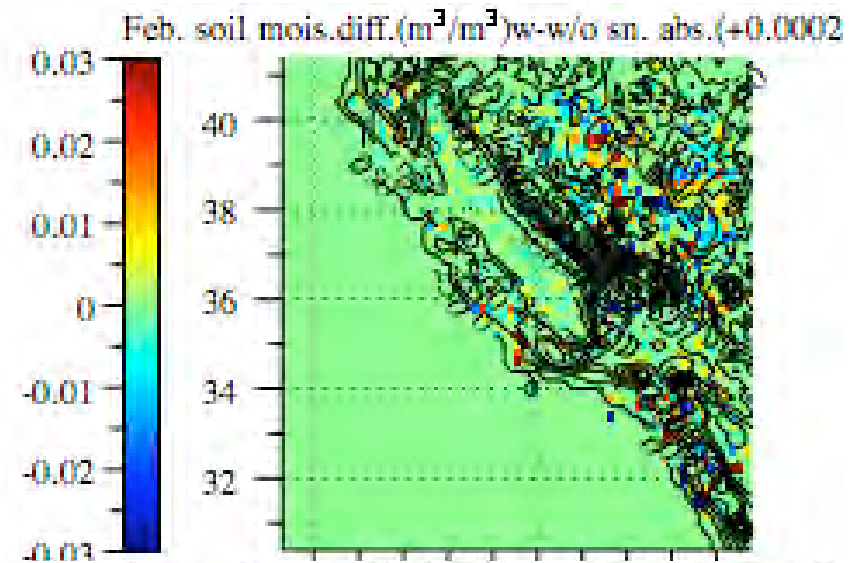
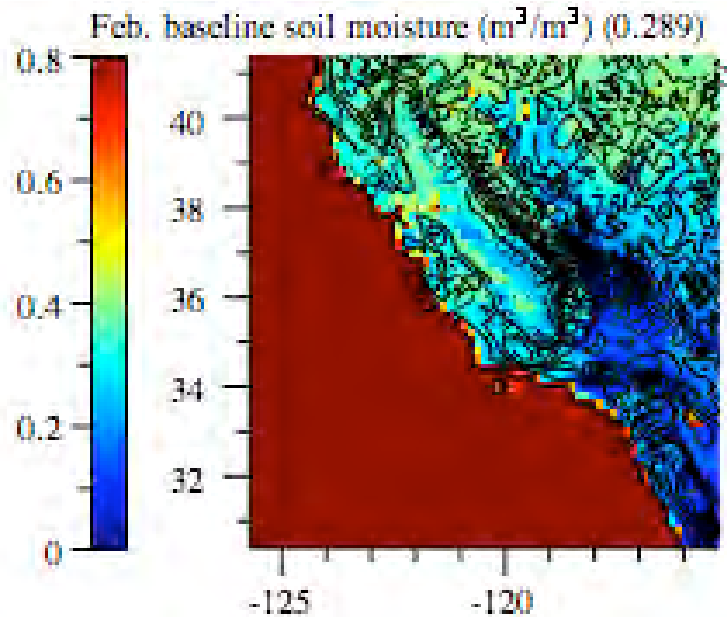
BC and soil dust
absorption in snow
reduced Feb. snow
albedo by 0.32%

Feb. Snow Depth, Diff. Due to Abs.



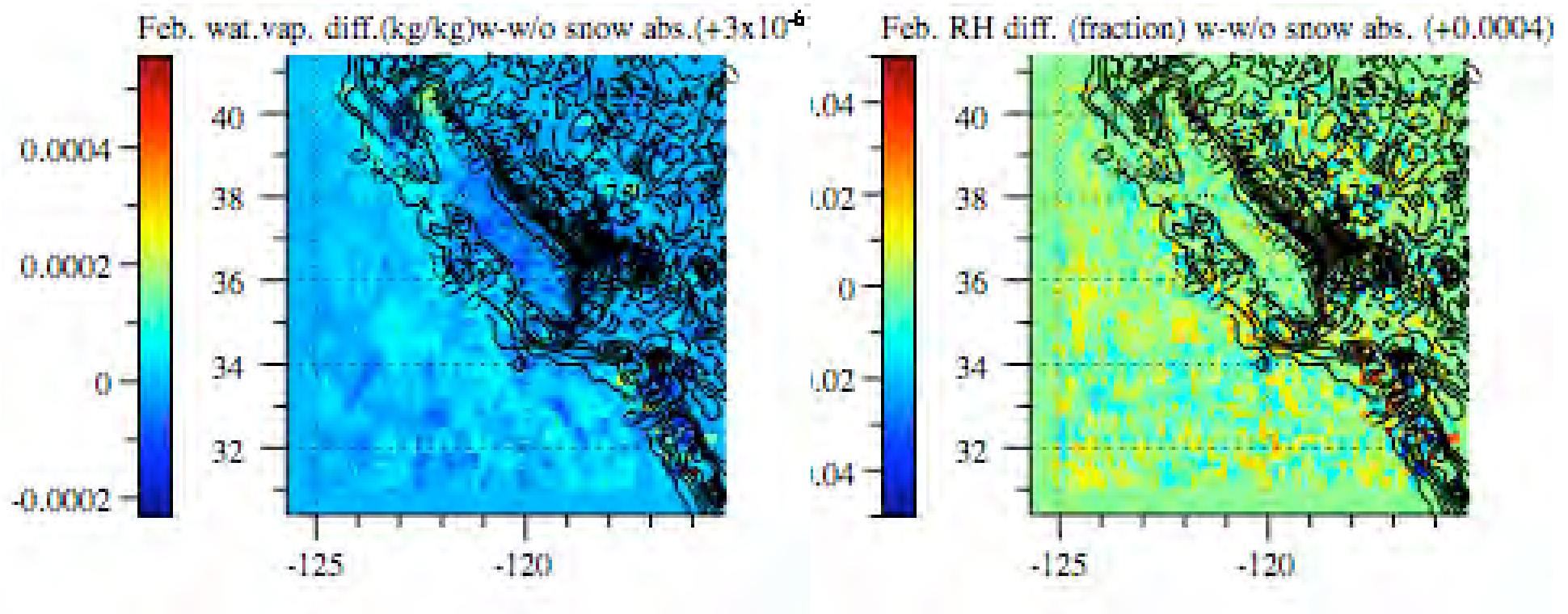
BC and soil dust
absorption in snow
reduced snow depth by
0.5%

Feb. Soil Moist, Diff. Due to Abs.



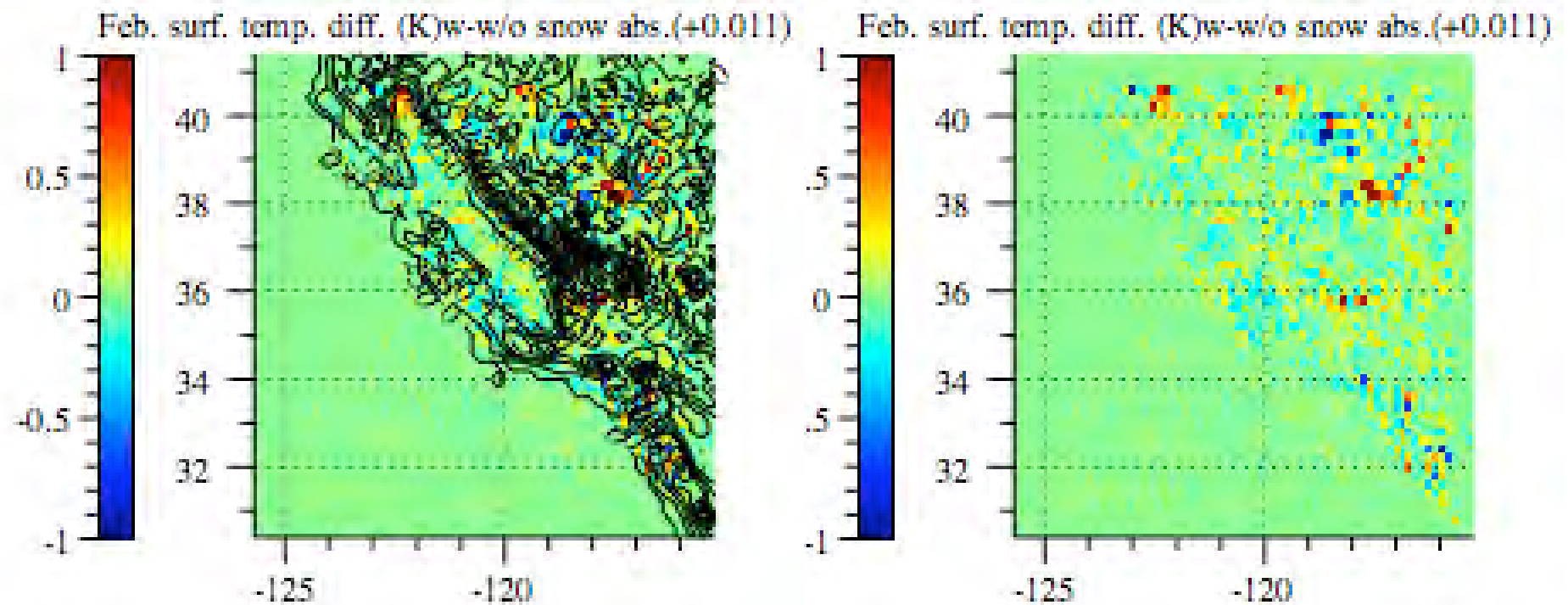
BC and soil dust absorption
in snow increased surface
soil moisture by 0.07%

Feb. Water Vapor, RH Diff. due to Absorption



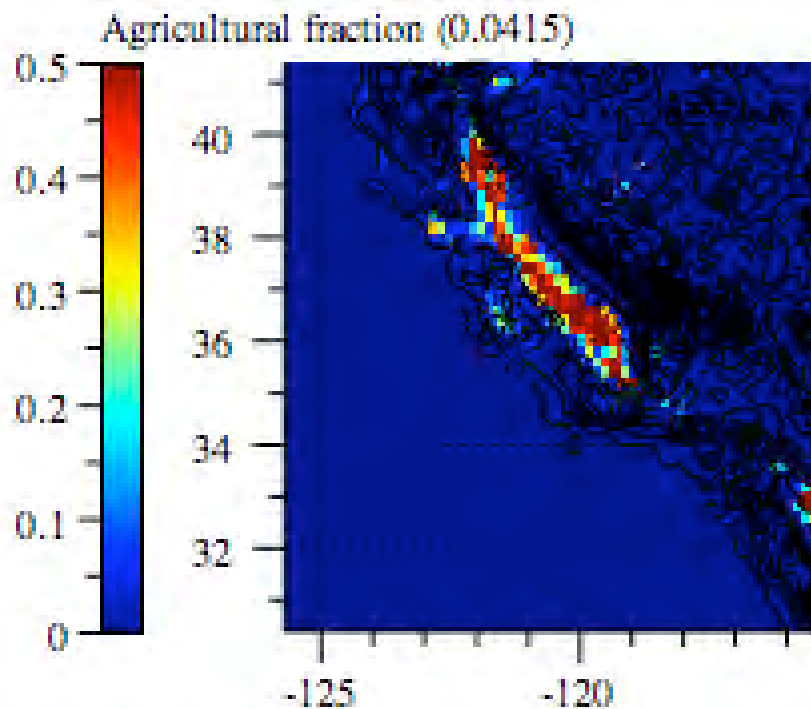
BC and soil dust absorption in snow increased
water vapor 0.1% and RH 0.04%

Surface Temperature Diff. Due to BC+Soildust Absorption in Snow

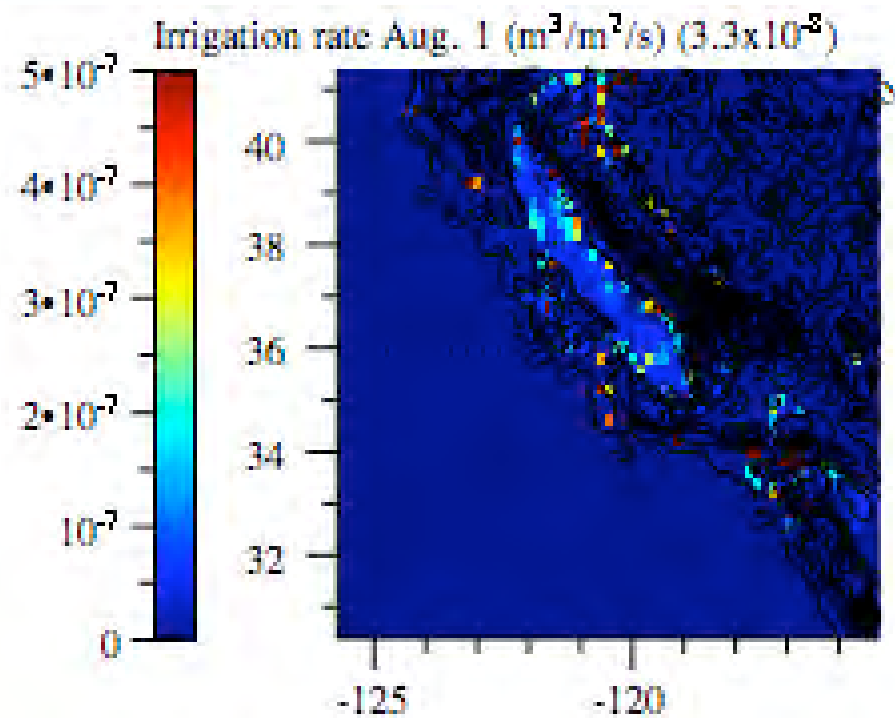


BC and soil dust absorption in snow
increased surface temperature by 0.011 K

Agriculture Fraction and Irrigation Rate (for one day)

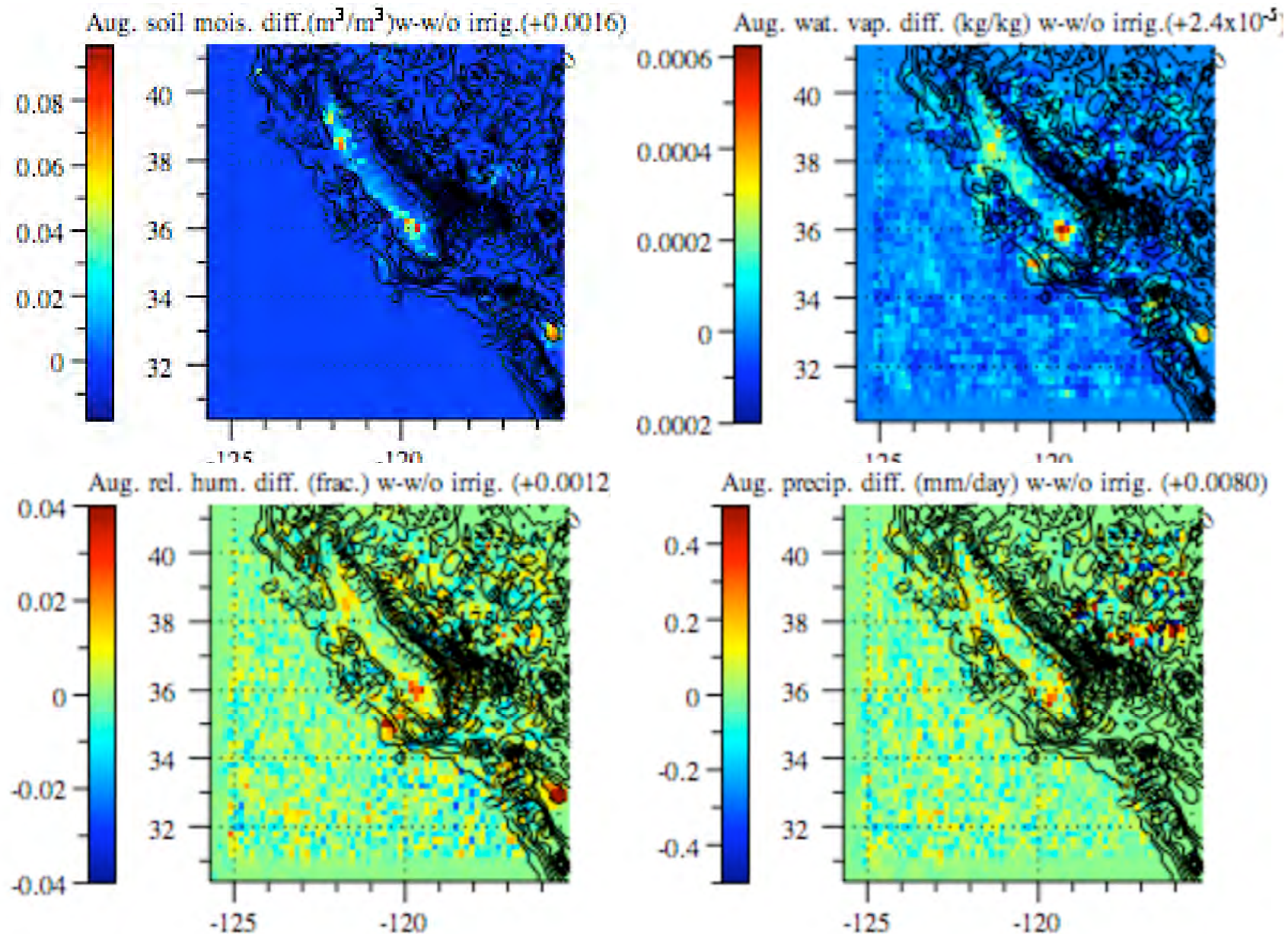


Data from USGS (1999)
Combination of 5 agric. classes

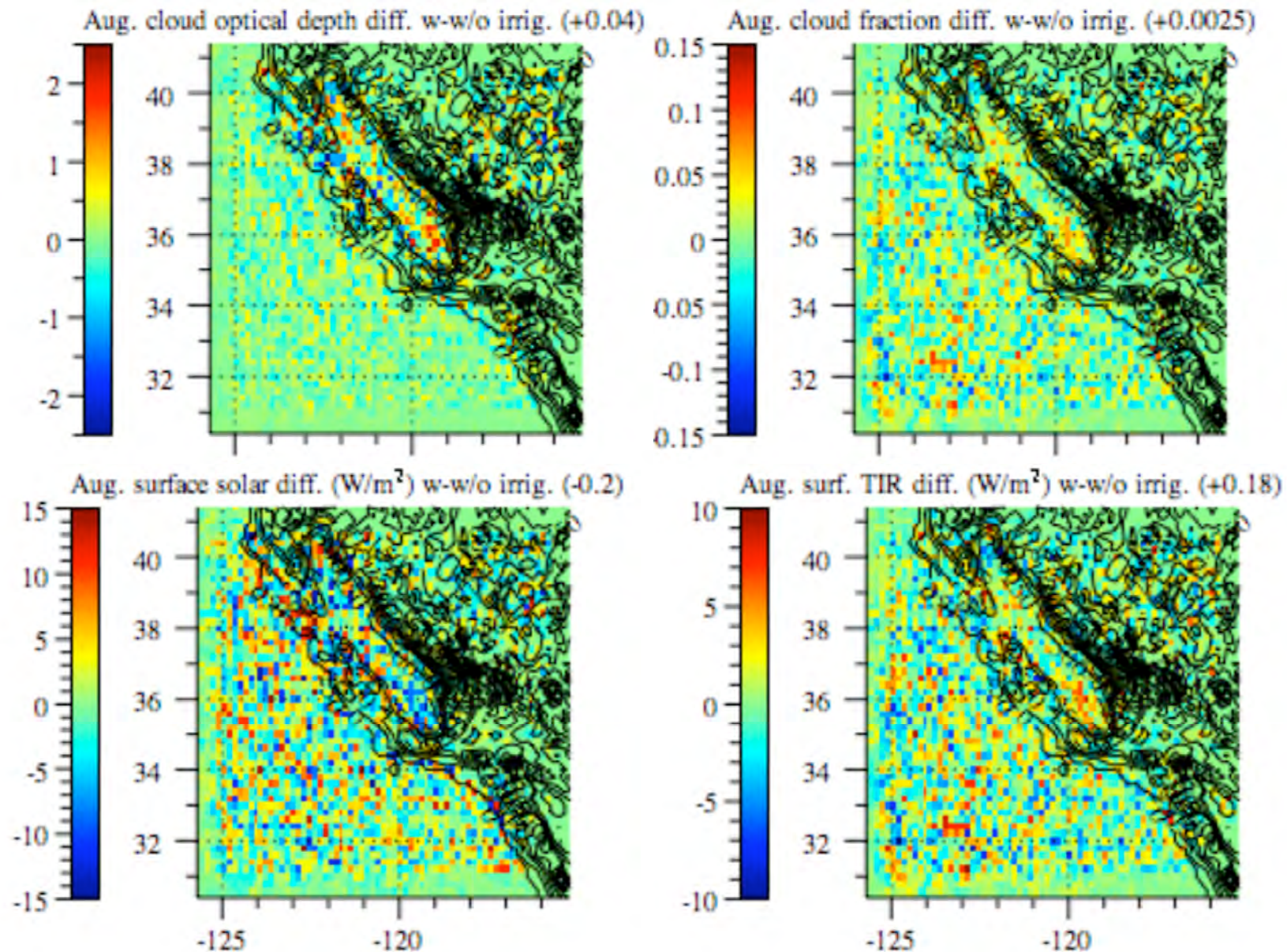


Data from
Salas et al. (2005)

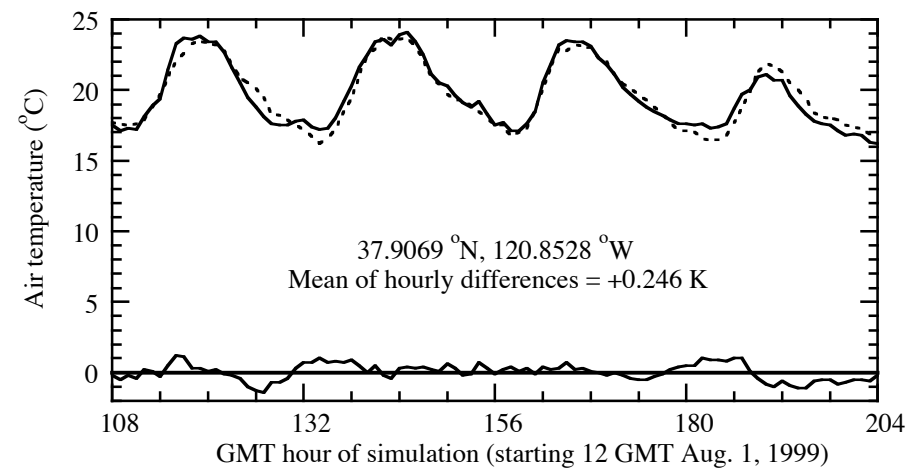
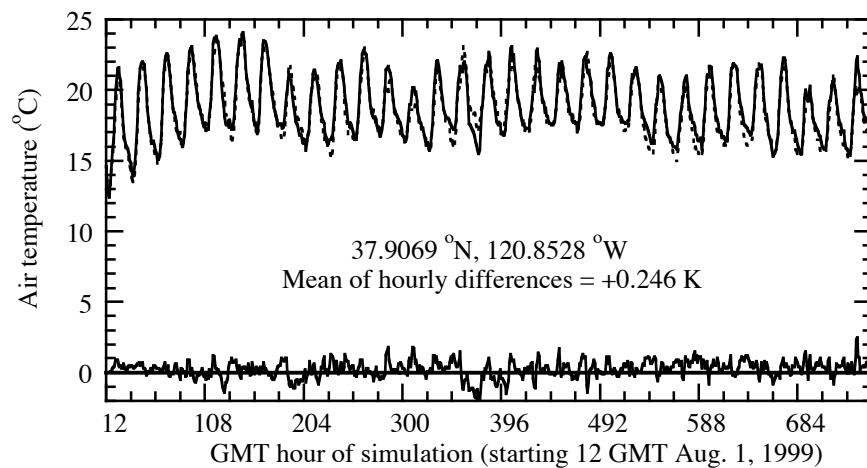
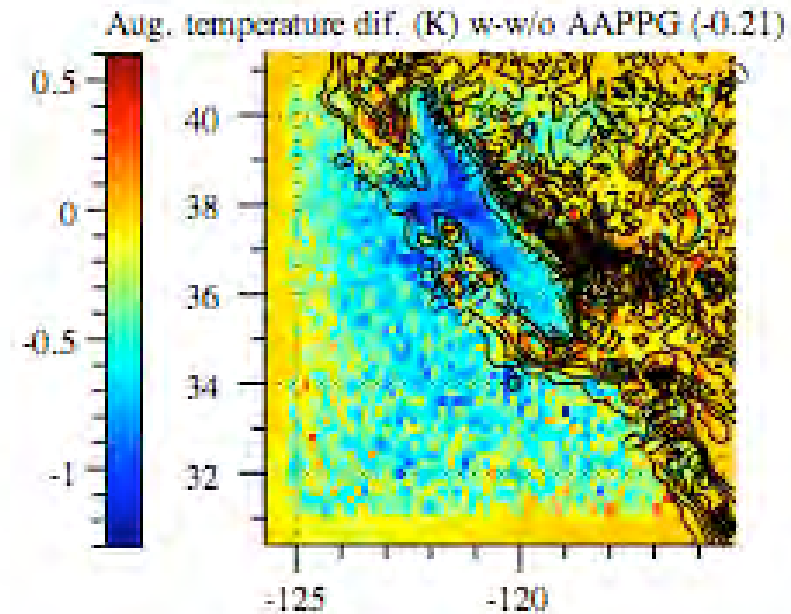
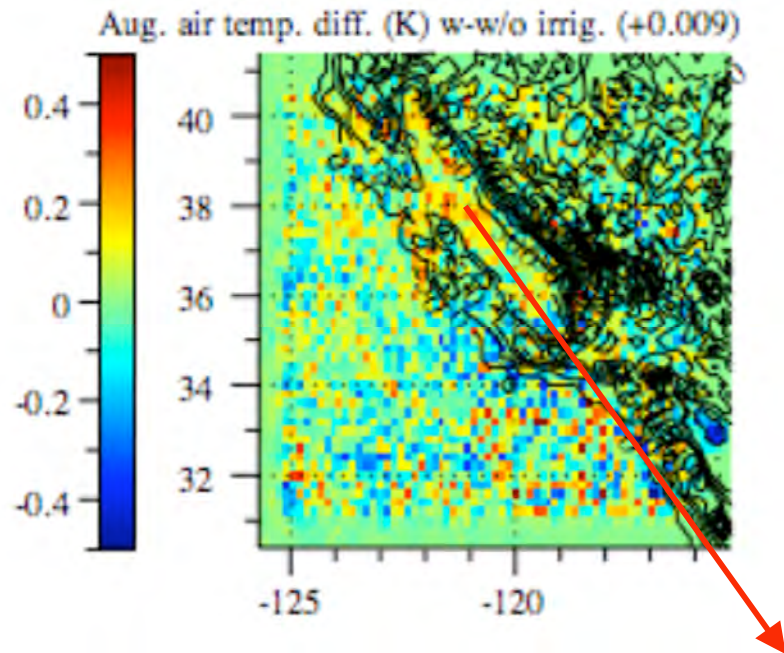
Soil Moist/Wat Vap/RH/Prec. Diffs. From Irrig.



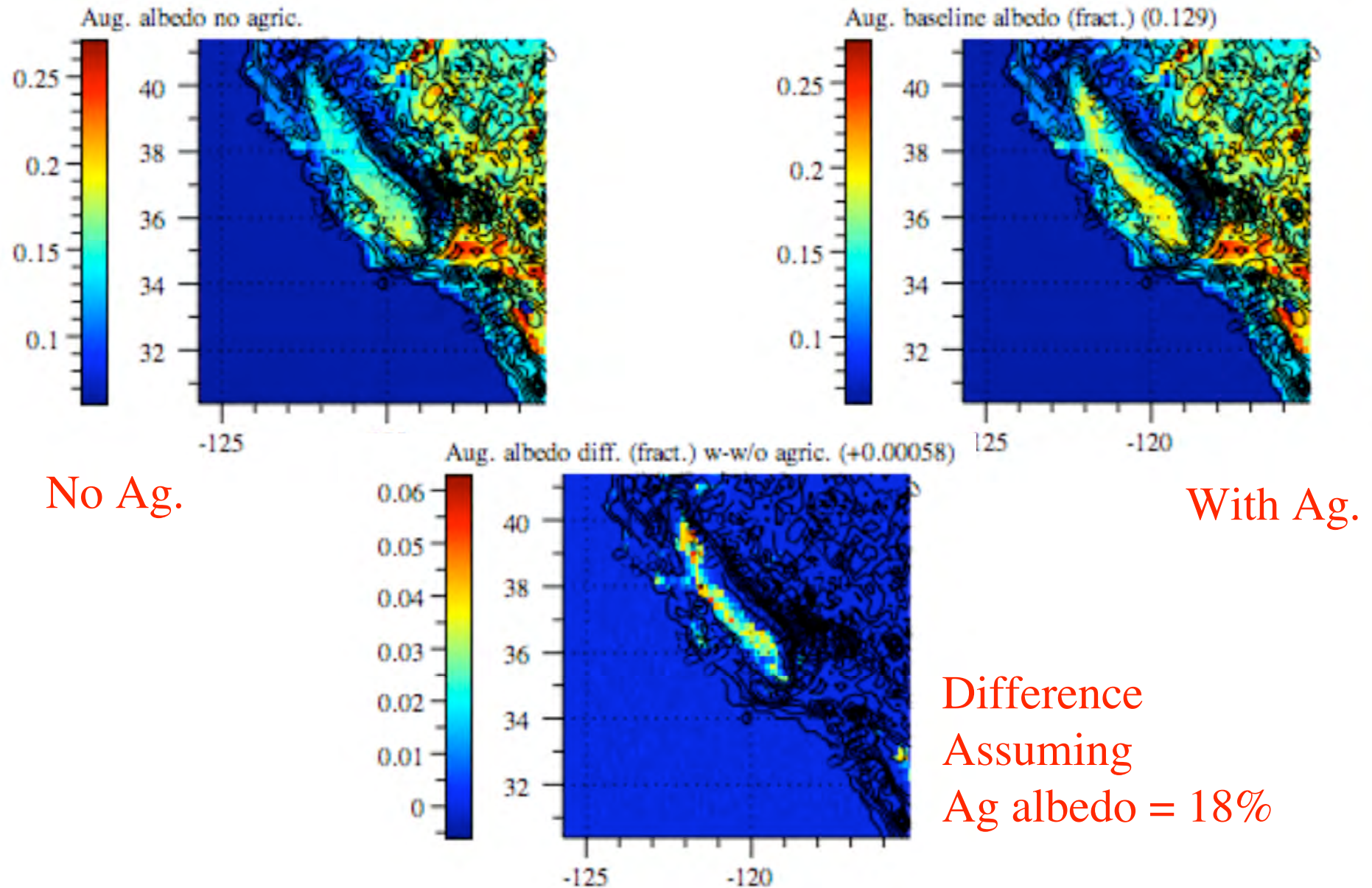
Cloud OD/Fract, Surface Sol/IR Diffs



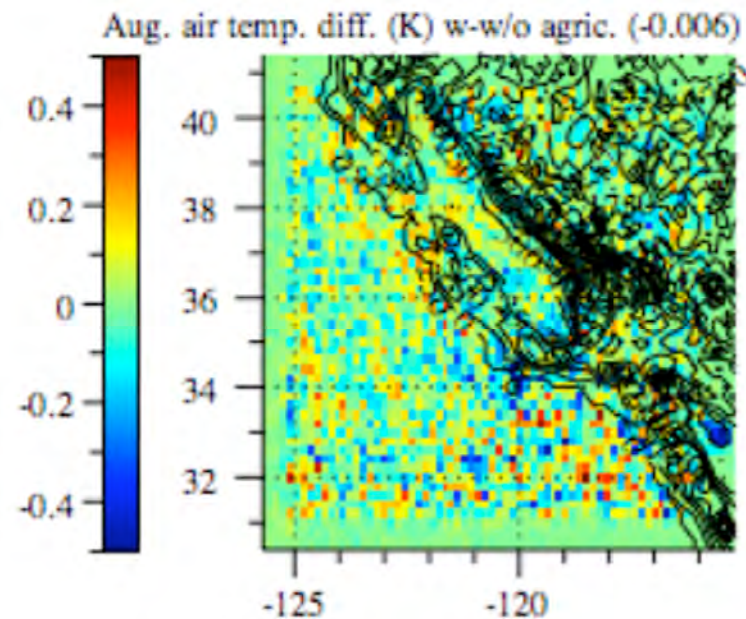
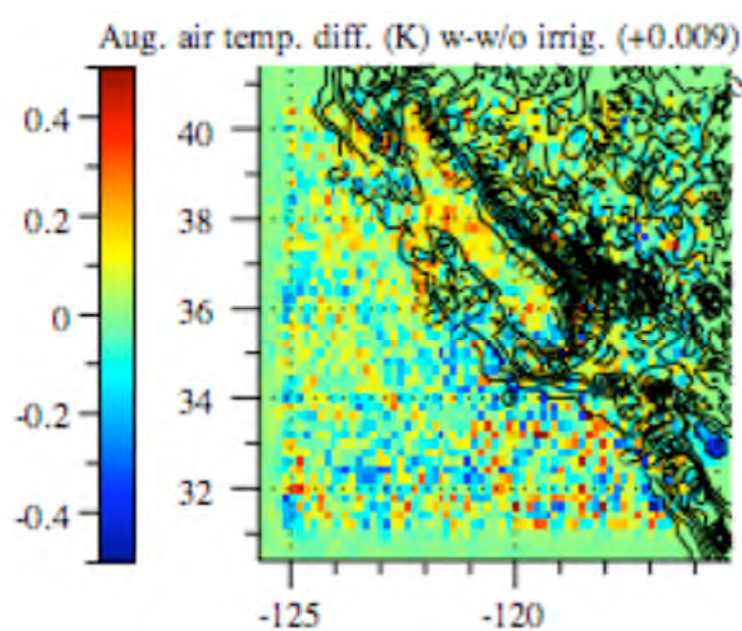
Air Temp Diffs. Due to Irrig. v. Aer.



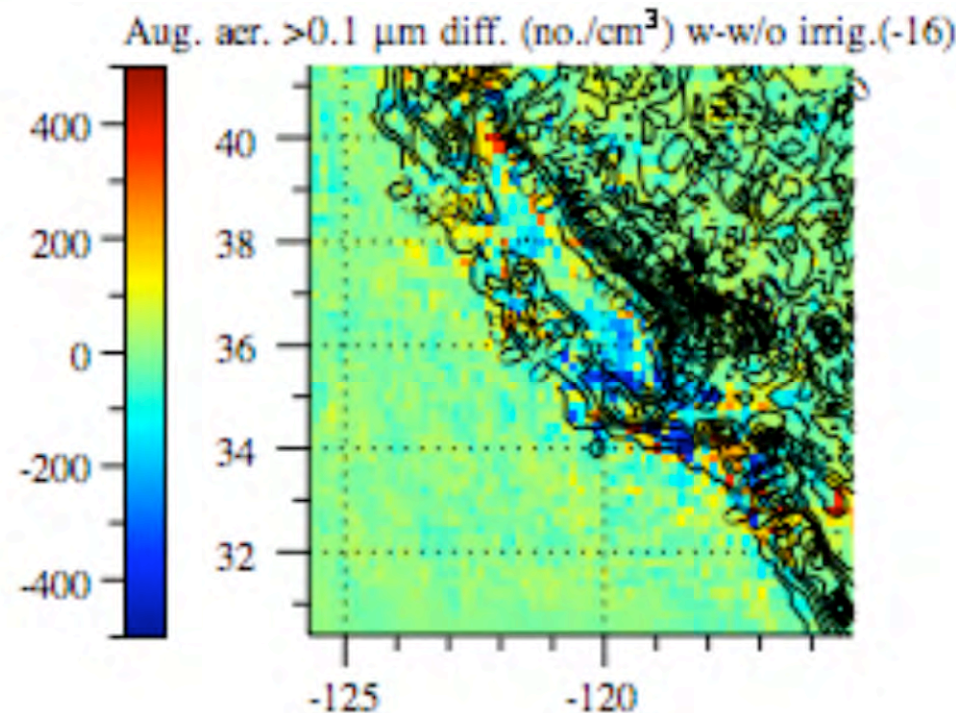
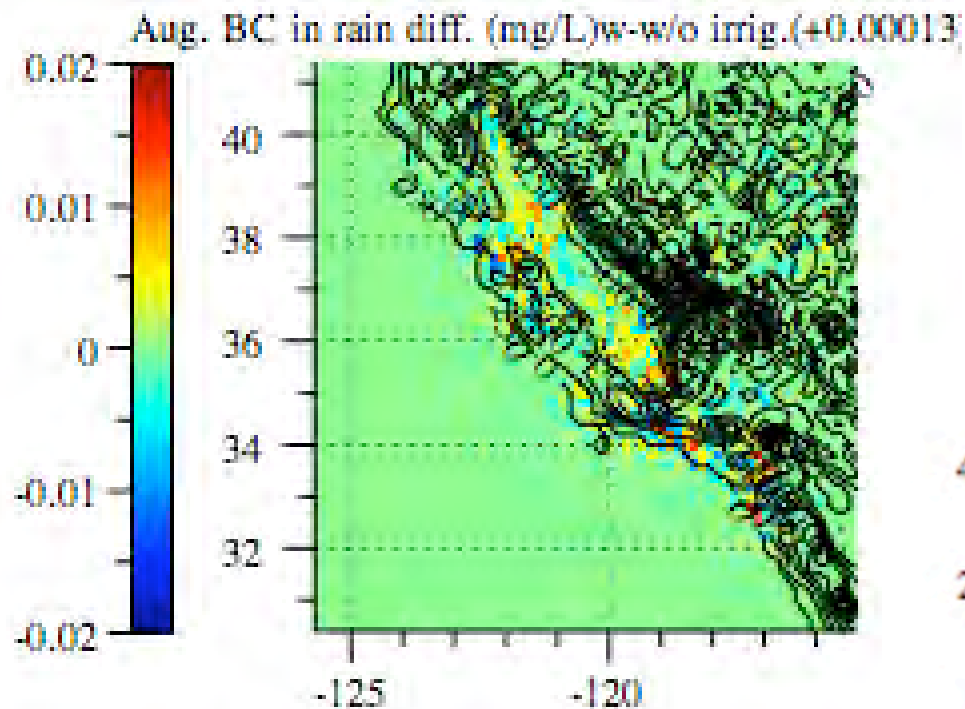
Albedo Change Due to Agriculture



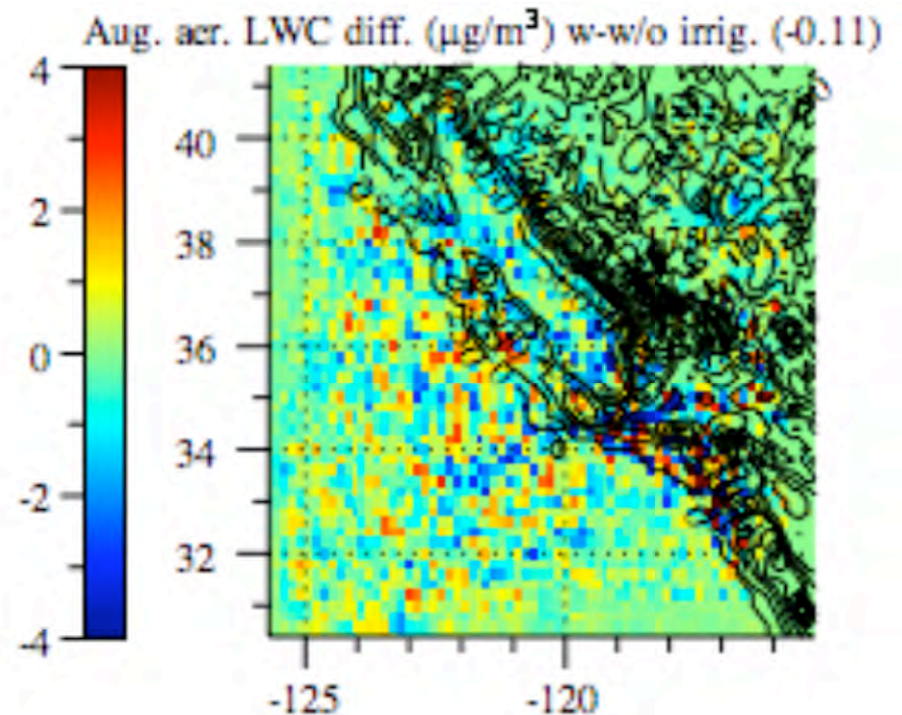
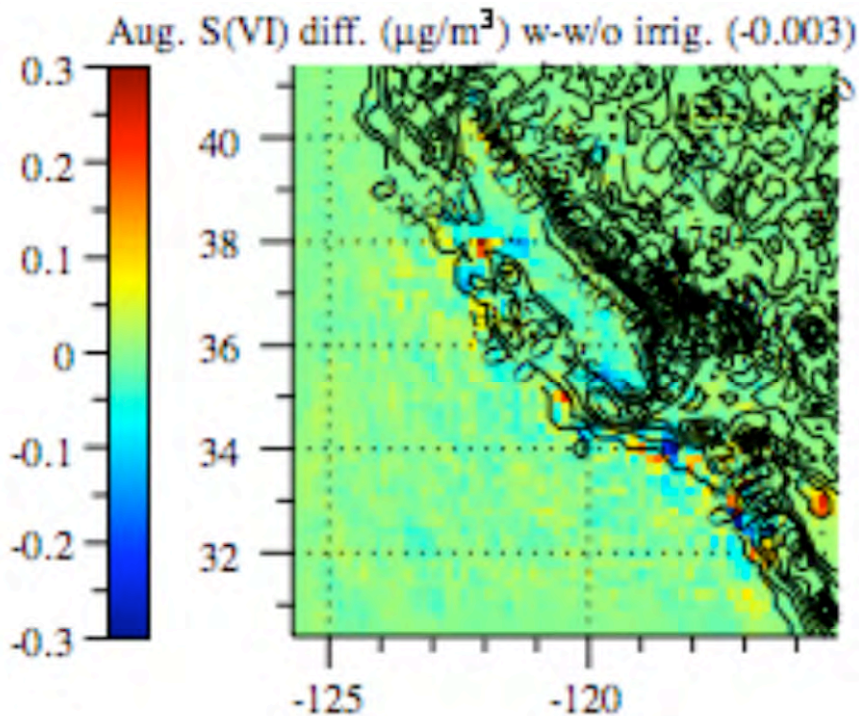
Air Temperature Change Due to Irrig. Only and due to Irrig+Albedo



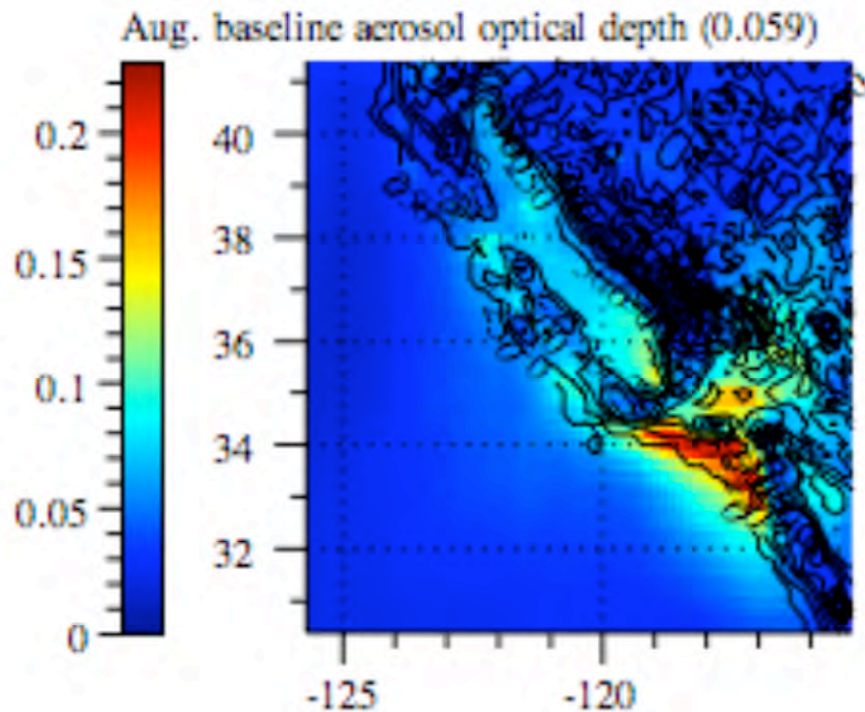
Aug. Diff. in Rainwater BC and Aer. Number >100 nm due to Irrigation



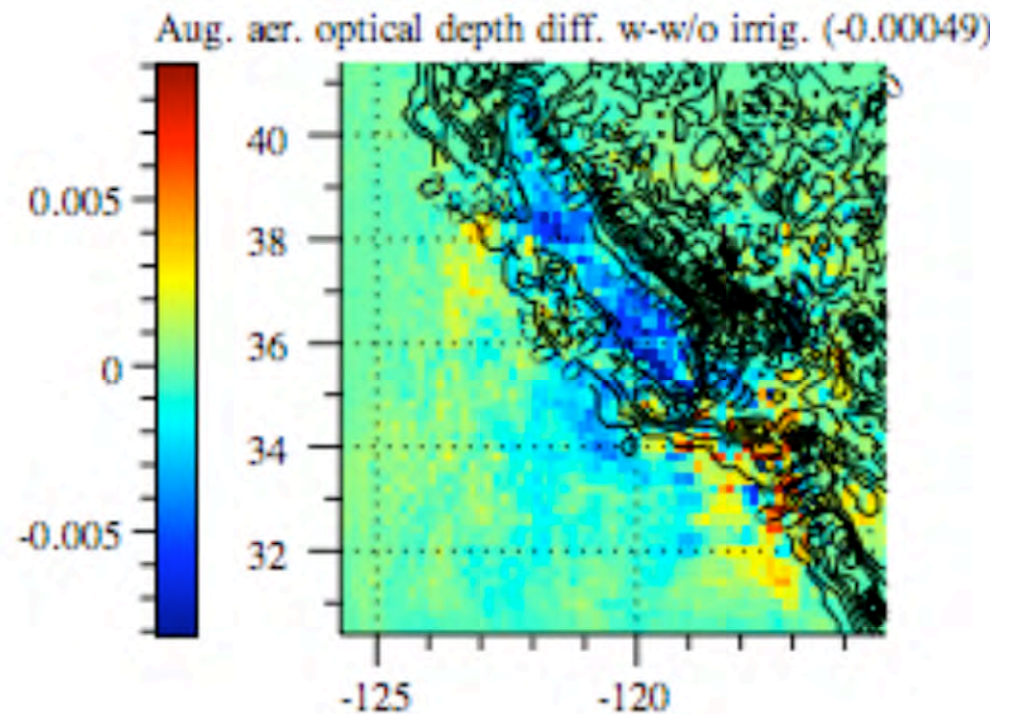
Aug. Difference in Aerosol S(VI) and Liquid Water Due to Irrigation



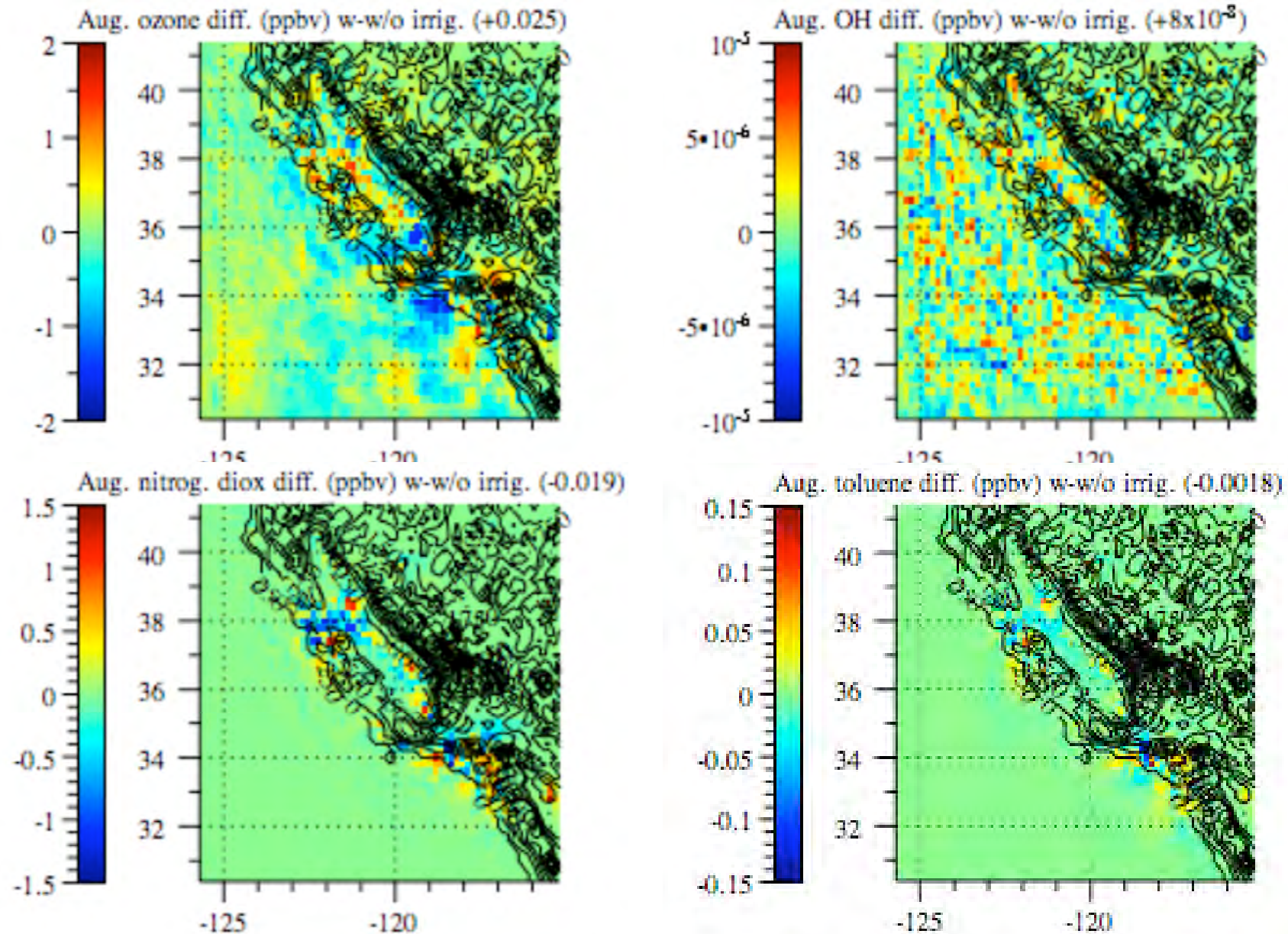
Baseline AOD and AOD Difference Due to Irrigation



0.83% reduction



Ozone, OH, NO₂, Toluene Diffs.



February Effects in California of BC and Soildust Absorption in Snow

Increased surface temperature over land by 0.011 K

Reduced snow albedo by 0.3%

Reduced snow depth by 0.5%

Increased near-surface soil moisture by 0.07%

Increased near-surface water vapor over land by 0.1%

Increased the near-surface relative humidity over land by 0.04%

August Effects of Irrigation in Calif.

Increased (over land)

soil moisture by 0.78% ($0.016 \text{ m}^3/\text{m}^3$)

near-surface water vapor by 0.25%

the relative humidity by 0.12%

cloud optical depth by 1.4%

cloud fraction by 0.93%

precipitation (fog deposition) by 2.2%

surface thermal-IR by 0.21% ($+0.18 \text{ W/m}^2$)

near-surface air temperature by 0.009 K

(greater incs. in night mins than decs. in day maxs)

(compares with -0.006 K when include ag. albedo)

(compares with -0.21 K due to aerosol particles)

near-surface OH by 0.12%

near-surface ozone by 0.06% ($+0.025 \text{ ppbv}$)

August Effects of Irrigation in Calif.

Decreased (over land)

surface solar radiation by 0.08% (0.20 W/m²)

aerosol optical depth by 0.83%

aerosol number by 0.5%

aerosol sulfate mass by 0.68%

aerosol soildust mass by 2.7%

larger than precip. increase because irrigation and
precip. reduced wind-blown soildust emissions too.

aerosol LWC by 1.8%

nitrogen dioxide by 0.58%

toluene by 0.76%